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Locomotor activity and fitness of α-Gpdh and Adh genotypes in Drosophila melanogaster.

The functional significance of allozyme variants is still a matter of dispute: how much of this variation is selectively neutral?

For the α-Glycerophosphate dehydrogenase-1 (α-Gpdh-1 locus in D.melanogaster) a positive relation between biochemical activity and ability to fly was established: null mutants are unable to fly (1). Marked genotype-alcohol interaction is proved for alcohol-dehydrogenase (Adh) variants (2). We investigated the problem: can environmental alterations change the fitness relations of α-Gpdh and Adh variants? In this respect we studied the influence of temperature on "locomotor activity" and "mating success."

Drosophila stocks: "Groningen", four lines homozygous for Adh (first letter) and α-Gpdh (second letter) alleles: FF, FS, SF and SS. "Curacao" two lines homozygous for Adh alleles: F and S (both α-Gpdh F). "Haren", Adh like "Curacao", variable for α-Gpdh.

The flies tested were 4-5 days old and had been cultured at low density at 25°C on a sucrose-yeast-agar medium. They were kept two days at experimental temperature and hereafter tested (60 ♂♂ or ♀♀) in a "race-track" (Figure 1) for three minutes (4 replicates).

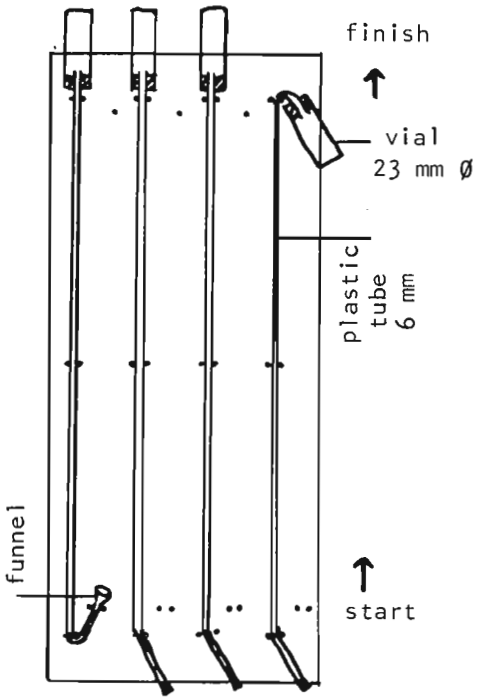

FIGURE 1.

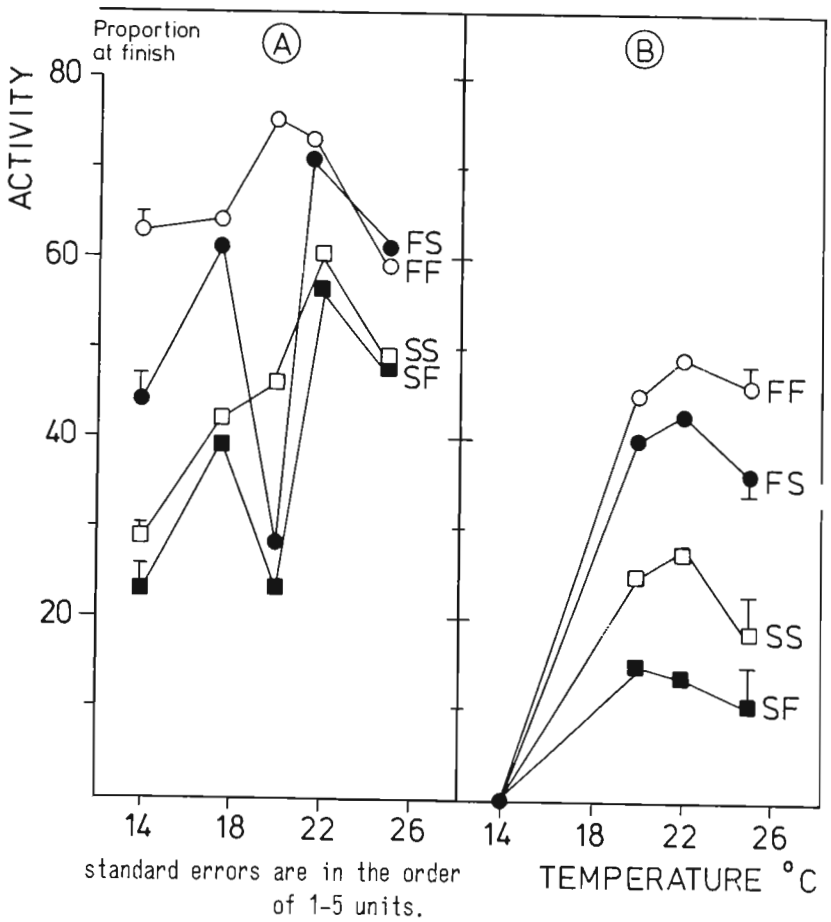

FIGURE 2. →

standard errors are in the order of 1-5 units.

Experiments. 1. Locomotor activity of the "Groningen" lines. The experiment was designed to investigate differences in locomotor activity between the four "Groningen" lines.

Figure 2 shows activity for ♂♂ (percentages, transformed to angles) at five temperatures in two independent experiments: A and B. The FF and FS lines are the most active genotypes in both experiments and at all but one (20°C, exp. A) temperature. The same holds for females but their activity is lower than in males, e.g., at 22°C: FF 32.3±1.0; FS 31.4±3.6 SF 13.8±1.9; SS 15.0±2.5 (compare with B).

So, from the "Groningen" population the two lines homozygous for the Adh-F allele are the most active lines.

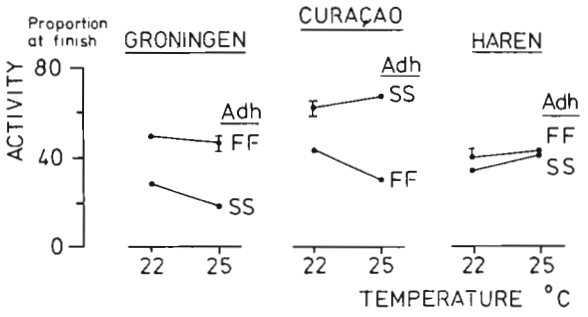

FIGURE 3.

Table 1. Number of females with progeny/male.

Temperature	Genotype			
	FF	FS	SF	SS
18°	1.0	1.5	1.4	1.4
20°	1.7	2.1	2.2	2.5
25°	3.2	3.4	3.4	3.4

(all means sharing the same line are not sign. different; x^2-tests; $P<0.025$).

2. Locomotor activity in other populations. To discriminate between effects of the Adh-gene and other genes associated with the Adh-locus, we measured activity of two other Adh strains with different geographical origin in the "race-track". Figure 3 shows a comparison of the three populations at two temperatures: In "Groningen": activity of FF exceeds activity of SS; in "Curacao" activity of FF exceeds SS; in "Haren" activity of FF equals activity of SS. The conclusion is justified that genes other than the Adh gene are responsible for the differences in locomotor activity.

3. Mating success in the "Groningen" lines. To examine the relation between activity and fitness, mating success of males (from experiment 1B) was measured.

Single males were presented (8 hours) to four females, one from each genotype. In Table 1 the number of fertilized females/male is shown for each of three temperatures. The most active genotype FF fertilized a lower number of females than the slow genotypes at all temperatures (sign. at 18° and 20°C). Since the number of offspring/♂/♀ with progeny was not significantly different for genotypes and temperatures, we can conclude that in this case activity is correlated negatively with mating success.

Discussion: Differences in locomotor activity were observed between allozyme genotypes in Drosophila melanogaster.

Activity of the Adh-F genotypes in the "Groningen" strain was higher than the activity of the Adh-S genotypes. There was no relation between activity and α-Gpdh-1 alleles (Figure 2). In a comparison of Adh variants from three geographically different strains, the results showed that not the Adh gene itself, but other "factors", associated with the specific Adh variants, must be responsible for the differences in activity between the strains (Figure 3).

To examine the relation between locomotor activity and "fitness", mating success of males was studied.

The number of females fertilized by the most active genotype FF was significantly lower than the numbers fertilized by the other genotypes at 18°C; at 20°C the FF and FS genotypes were both less successful than the two Adh-S genotypes; at 25°C there was no difference between the genotypes. So, at low temperature, it seems justified to state that: "slow and steady wins the race."

The Adh and α-Gpdh loci are localized on chromosome 2. It is known that genes for a number of behavioral characters--like locomotor activity, genotaxis and phototaxis--are localized on the X-chromosome of species of Drosophila (Table II, ref (3)).

Additional evidence for locomotor activity genes on the X-chromosome of D.melanogaster is presented in reference (4).

Factors which determine the differences in activity between the four "Groningen" genotypes must be genes different from these genes on the X-chromosome. In the "Groningen" population high fitness (mating success of ♂♂) was not combined with high locomotor activity ("FF" and "FS" genotypes) and high or low activity was not a pleiotropic effect of the Adh or α-Gpdh-1 alleles. It can also be said that the genes influencing flying ability (ref. 1) are different from the genes determining our vertical locomotor activity since the last are not related to the α-Gpdh-1 locus.

References: (1) O'Brien, S. & Y.Shimada 1974, J.Cell Biol. 63:864-882; (2) Bijlsma-Meeles, E. & W.vanDelden 1974, Nature 247:369-371; (3) van Dijken, F., M.P.Y.W.vanSambeek & W.Scharloo 1979, Behavior Genetics 9:563-570; (4) Wilson, R., B.Burnet, L.Eastwood & K.Connolly 1976, Genetical Research 28;75-88.